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Numerical Investigation of Compact Heat Exchanger using Nanofluids

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Abstract – *The thermal conductivities of Nano fluids containing solid particles are generally greater than base fluids. The nano fluids can be used to significantly enhance the heat transfer characteristics of compact heat exchanger. The current research is intended to enhance heat transfer characteristics of fluids using nanoparticles. The design heat exchanger is done using Creo software and numerical simulation is conducted using CFX. The heat transfer characteristics and pressure drop is evaluated. The Nano fluid investigated is* Al_2O_3*/water and turbulence model used for the analysis is RNG k-epsilon. The CFD is a viable tool in determining heat transfer characteristics of finned tube heat exchanger. The use of nanofluid has found to increase the heat transfer characteristics of finned tube heat exchanger. The heat transfer increased by 12.2% increased with use of aluminium oxide nano fluids.*

Key Words: (Nanofluids, Finned tube heat exchanger, CFD

1.INTRODUCTION

The advent of high heat flow processes has created significant demand for new technologies to enhance heat transfer. The thermal conductivities of Nano fluids containing solid particles are generally greater than values predicted by theories of transport in heterogeneous materials. The use of nano particles like Cu, Ag shown to have enhanced thermal conductivity of fluids. The "large intrinsic thermal conductivity of carbon-based nanostructures, combined with their low densities compared with metals, make them attractive candidates for use in nanofluids" [1].

2. LITERATURE REVIEW

Mao-Yu Wen, Ching-Yen Ho [2] have conducted numerical investigation on wavy and compounded fin for different ranges of Reynolds number. The external air velocity ranged from 1.2m/s to 3m/s. The research findings have shown that compounded fins have better performance as com-pared to other types.

Parinya Pongsoi, Somchai Wong wises [3] have conducted numerical investigation on L shaped tube heat exchanger to determine HTC and Nusselt number. The research findings have shown that fin pitch have significant effect on performance of heat exchanger.

Nuntaphan, T. Kiatsiriroat, C.C. Wang [4] have conducted CFD analysis on heat exchangers with crimpled spiral configurations and with varying fin diameters. The research findings have shown an reduction in pressure drop and heat transfer when fin diameter is increased.

Parinya Pongsoi [5] have conducted experimental analysis on multi-pass configured heat exchanger. The heat exchanger operations are performed for Reynolds number ranging from 4500 to 13000. The research findings have shown colbourn j factor is not influenced by fin pitch. The friction factor increased for a fin pitch value of 6.2mm.

3. PROPOSED WORK

The current research is intended to enhance heat transfer characteristics of fluids using nanoparticles. The design heat exchanger is done using Creo software and numerical simulation is conducted using CFX. The heat transfer characteristics and pressure drop is evaluated. The Nano fluid investigated is Al_2O_3/water and turbulence model used for the analysis is RNG k-epsilon.

4. METHODOLOGY

The CFD analysis of heat exchanger involves 3 different stages i.e. preprocessing, solution and post processing.

- **Preprocessing Stage**

The finned tube heat exchanger CAD design is developed in Creo design software. The semi-circular and rectangular sketch is developed and then extruded to create. The developed model of finned tube heat exchanger is shown in figure 1 below. The dimensions of finned tube heat exchanger are taken from literature [6].

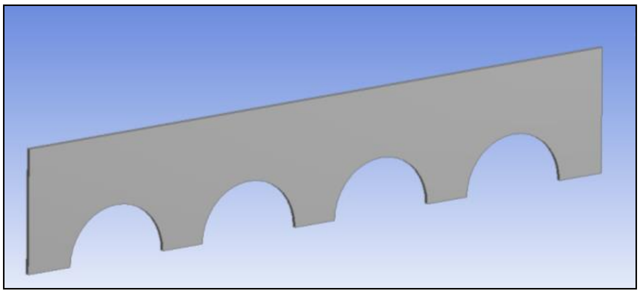

Figure 1: Finned tube heat exchanger design

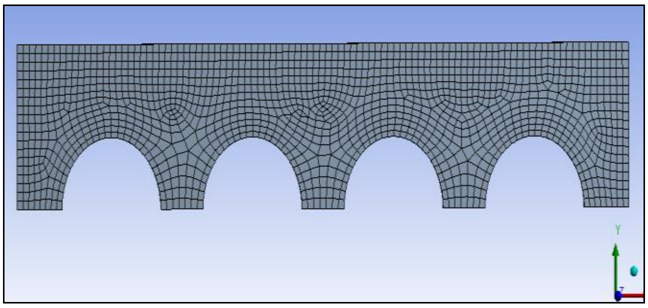

Figure 2: Discretized model of heat exchanger design

The heat exchanger design is meshed with normal inflation and smooth transition as shown in figure 2 above. The model is discretized with brick elements.

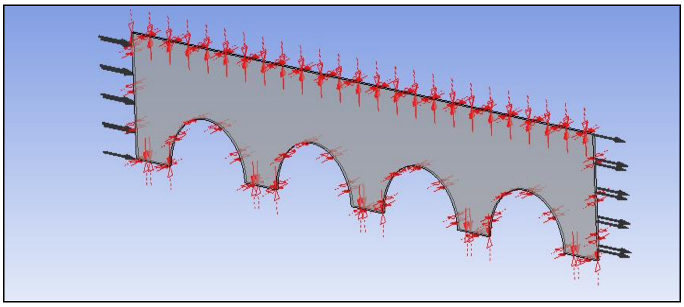

Figure 3: Applied boundary conditions

The domain is defined with fluid type and reference pressure set to 1atm. The turbulence model is defined as RNG k-epsilon turbulence. The inlet/outlet and symmetric boundary conditions are defined for heat exchanger. The air inlet is defined as 0.4m/s with 300K temperature. The symmetric boundary condition is defined at both the side surfaces of heat exchanger. The convergence criteria and residual target values are defined.

- **Solution Stage**

The software computed the RMS residual values at different nodes and interpolated the results for entire element edge length. The rms residual plots of mass, momentum and energy are generated.

- **Postprocessing Stage**

The post-processing stage of CFD involves viewing output parameters i.e. pressure, velocity and temperature.

5. RESULTS AND DISCUSSION

The simulation results are obtained for water and aluminium oxide nano fluid. The simulation results include temperature plot, velocity plot and pressure plot.

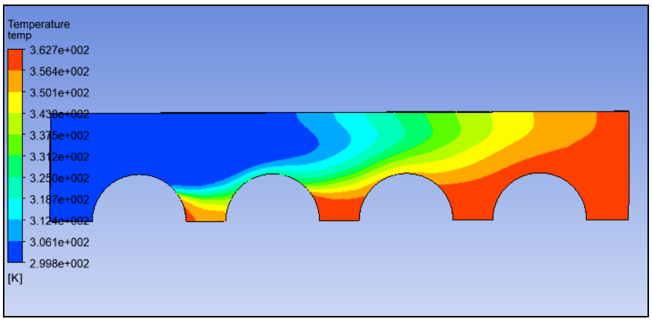

Figure 4: Temperature plot across heat exchanger for water

The maximum temperature is observed at fluid exit section of the tube with magnitude of more than 356K. The fluid temperature is minimum near the fluid inlet.

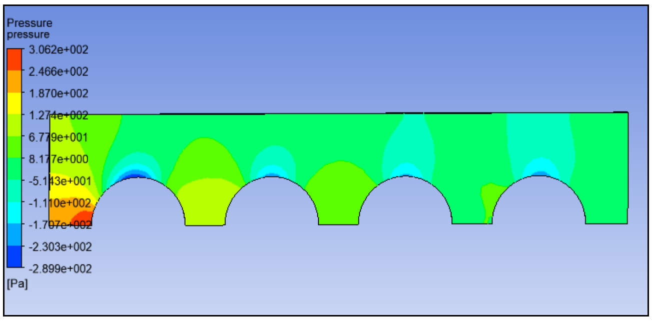

Figure 5: Pressure plot across heat exchanger for water

The pressure plot is also generated for the analysis as shown in figure 5 above. The pressure is maximum near the fluid inlet at the frontal tube. The maximum pressure is 306.2Pa at the fluid inlet and pressure at the outlet is 67.79Pa.

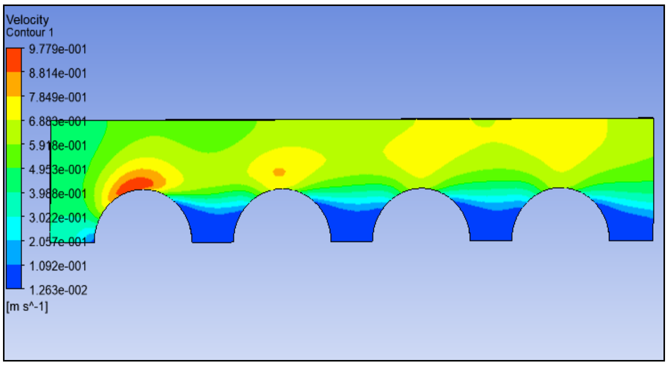

Figure 6: Velocity plot across heat exchanger water

The velocity profile is generated for finned tube heat exchanger as shown in figure 6 above. The plot shows maximum velocity at the 1st tube with magnitude of .97 m/s.

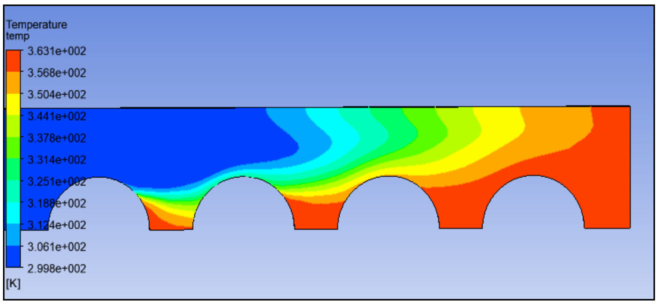

Figure 7: Temperature plot across heat exchanger for aluminium oxide nano fluid 3%

The maximum temperature is observed at fluid exit section of the tube with magnitude of more than 355K. The fluid temperature is minimum near the fluid inlet.

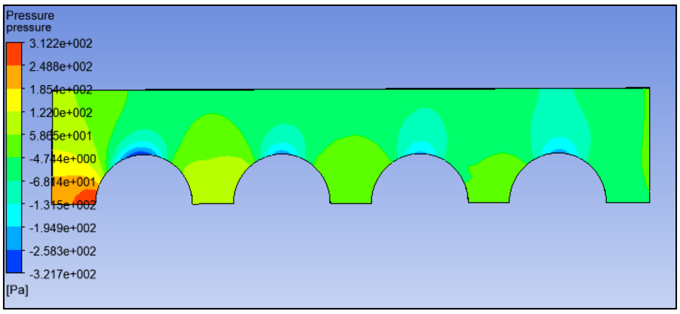

Figure 8: Pressure plot across heat exchanger for aluminium oxide nano fluid 3%

The pressure plot is also generated for the analysis as shown in figure 8 above. The pressure is maximum near the fluid inlet at the frontal tube. The maximum pressure is 312Pa at the fluid inlet and pressure at the outlet is 58.6Pa.

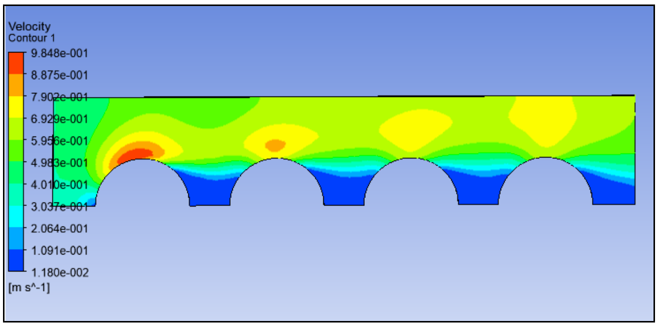

Figure 9: Velocity plot across heat exchanger aluminium oxide nano fluid 3%

The velocity profile is generated for finned tube heat exchanger as shown in figure 9 above. The plot shows maximum velocity at the 1st tube with magnitude of .94 m/s.

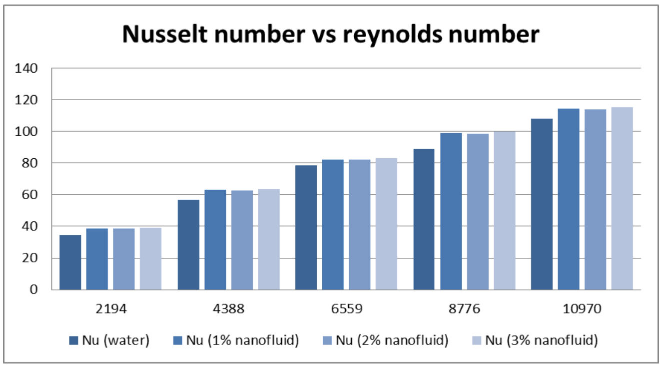

Figure 10: Velocity plot across

The Nusselt number comparison for different types of fluids is shown in figure 10 above. The plot shows minimum heat transfer characteristics for water and maximum heat transfer characteristics for nano fluids with 1% mass fraction.

6. CONCLUSION

The CFD is a viable tool in determining heat transfer characteristics of finned tube heat exchanger. The use of nanofluid has found to increase the heat transfer characteristics of finned tube heat exchanger. The heat transfer increased by 12.2% increased with use of aluminium oxide nano fluids. The use of nanofluid also increased the pressure drop across heat exchanger which ultimately increased the pumping power requirement.

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